

ARTIFICIAL NESTING STRUCTURES

FOR

THE DOUBLE-CRESTED CORMORANT

by

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ABSTRACT

Natural nesting habitat for the double-crested cormorant (*Phalacrocorax auritus*), consisting of flooded dead timber, has become limited in the midwest portion of the United States. Population trends have followed this decline in habitat and today the species is classified as endangered in Wisconsin. Artificial nesting structures, consisting of a pole with platforms, proved to be a successful substitute for natural nest sites on the George W. Mead Wildlife Area in central Wisconsin and thus provided an excellent method for rehabilitating deteriorating natural rookeries. Three platform types were tested in 1974. Platform Type-A had a chicken wire surface, Platform Type-B a lath surface, and Platform Type-C a box surface. Platform Type-B proved to be most successful and with minor modification was used almost exclusively for platform construction in 1975 and 1976. Cormorant use of the modified Platform Type-B was high in comparison to all others tested and it is recommended for further rookery restoration projects. Artificial structures, poles with attached platforms, are constructed of treated wood and have a life expectancy of 45 years. Platform use at the Mead rookery increased from 25.6% in 1974 to 57.5% in 1976 as deterioration of natural nest sites within the rookery accelerated. Production of fledged young per nest averaged 1.94 and 2.16 for nests in natural nest sites and artificial platforms respectively. Use of artificial platforms by the great blue heron (*Ardea herodias*) was documented each year of the study. A total of 3.8, 2.3, and 9.4% of all heron nests constructed in the rookery were in artificial platforms for 1974, 1975, and 1976, respectively. Production averaged 2.2 young per nest. Artificial structures should be placed within 25-ft of natural

nesting trees; platforms should be placed within the vertical height interval occupied by natural nests; platforms should be spaced 3-ft apart vertically for cormorants and 4-ft apart for herons; and consecutive platforms should be placed in 180° vertical rotation. Perching structures were also erected to provide perching sites in excessively deteriorated areas of the rookery. Total construction costs were \$125.00 per 4 platform structures and \$200.00 per 6 platform structures. Total construction cost per perching structure was \$97.75.

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INTRODUCTION

The double-crested cormorant (*Phalacrocorax auritus*) nests primarily in flooded dead timber over most of the midwest, although several rocky islands in lakes Michigan and Superior have been inhabited by colonies in the past (Anderson and Hamerstrom 1967). A common nester in most parts of Wisconsin in the 1940's, the cormorant is classified today as an endangered species (Wisconsin Department of Natural Resources 1979). Population declines attributed to habitat deterioration and human disturbance resulted in only a few scattered colonies in the southwestern and western portions of the state by the mid-1960's (Anderson and Hamerstrom 1967). The cormorant is also endangered in the neighboring states of Illinois (Illinois Department of Conservation 1978) and Michigan (Michigan Department of Natural Resources 1980) and is threatened in Minnesota (Henderson, Pers. commun.).

Cormorants often nest in company with other species. Anderson and Ellis (1966) reported the association of cormorants with great blue herons (*Ardea herodias*), black crowned night herons (*Nycticorax nycticorax*), common crows (*Corvus brachyrhynchos*), and gulls and terns.

Cormorants in the central Wisconsin Lake DuBay colony nested with the great blue heron. Knudsen (1951) reported approximately 400 nests of both species in 1949 and documented a decline to approximately 250 nests in 1951. The rookery is now extinct, due primarily to the loss of nesting trees. High pesticide levels produced significant egg shell thinning and may have contributed to the decline of this colony (Anderson et al. 1969).

Cormorant nesting habitat materialized in the Lake DuBay area in 1964 when areas adjacent to the Little Eau Plaine River on the George W.

Mead Wildlife Area (Mead) were flooded. Cormorant and heron activity was first noted at the Mead in 1967; by 1974 an established rookery of 28 cormorant and 75 blue heron nests existed. The cormorant population at the Mead expanded at an annual rate of approximately 25% since 1968.

Anderson and Hamerstrom (1967) state that during the decline of the Lake DuBay colony, cormorant use of newly flooded areas on the Mead was not uncommon. The last recorded nesting year of 1966 for the DuBay colony was followed by nesting of cormorants and herons at the Mead in 1967; it is possible that the Mead colony is a product of the Lake DuBay colony.

The flooded hardwood timber, which provided the nest substrate for the Mead colony was deteriorating at a rapid rate and the future of the colony looked dim when this study was initiated in 1974. The existing nesting trees were expected to disappear by 1980. Similar deterioration of nesting habitat has occurred throughout the midwest. Excessive loss of nesting habitat has occurred on the Agassiz National Wildlife Refuge in Minnesota where, in 1967, deterioration was so advanced that cormorants were nesting on the ground or on floating mats of vegetation (Cline and Dornfield 1968). Habitat deterioration has also occurred for the osprey (*Pandion haliaetus*) and the everglades kite (*Rostrhamus sociabilis plumbeus*); both endangered in their respective states of Michigan and Florida. Artificial nesting structures for the osprey (Postupalsky 1974) and artificial nest baskets for the kite (Sykes and Chandler 1974) have proven successful in providing nesting sites secure from the effects of deterioration and wind. Postupalsky (1974) reports that the Fletcher Pond colony, comprising approximately one-half of the osprey population of lower Michigan, has grown steadily since the introduction of artificial nest structures.

The purpose of this study was to design, erect, and test artificial nesting structures that would supplement the natural habitat of the double-crested cormorant.

STUDY AREA

The George W. Mead Wildlife Area is located in central Wisconsin, in Wood, Marathon, and Portage counties, 22.5 miles northwest of Stevens Point and 5.5 miles north of Milladore (Fig. 1). The Mead is 26,610 acres in size and characterized by 17 large impoundments created principally for waterfowl management. Townline Flowage, located in the central portion of the wildlife area was first flooded in 1964. The cormorant and heron rookery, researched in this study, is located in the extreme southeast corner of this 1,100 acre impoundment and is approximately 13.7 acres in size (Fig. 2). Water depths within the rookery range from 6-in to 8-ft. Soils consist of clay overlain with fine silt. Flooded dead timber consists principally of white ash (*Fraxinus americana*), silver maple (*Acer saccharinum*) and elm (*Ulmus sp.*).

Cormorant and Great Blue Heron Rookery

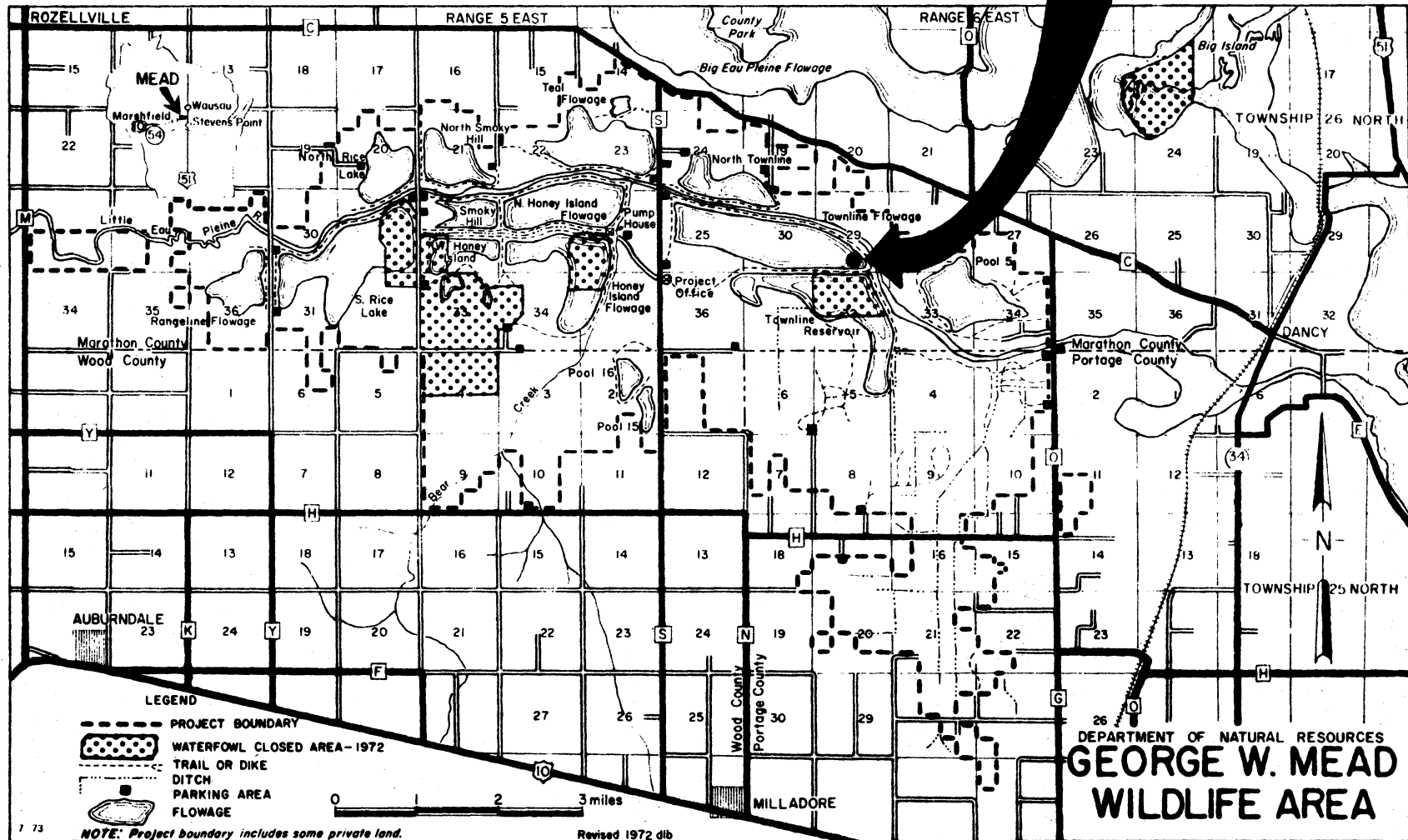


Fig. 1. Location of the George W. Mead Wildlife Area in Central Wisconsin.

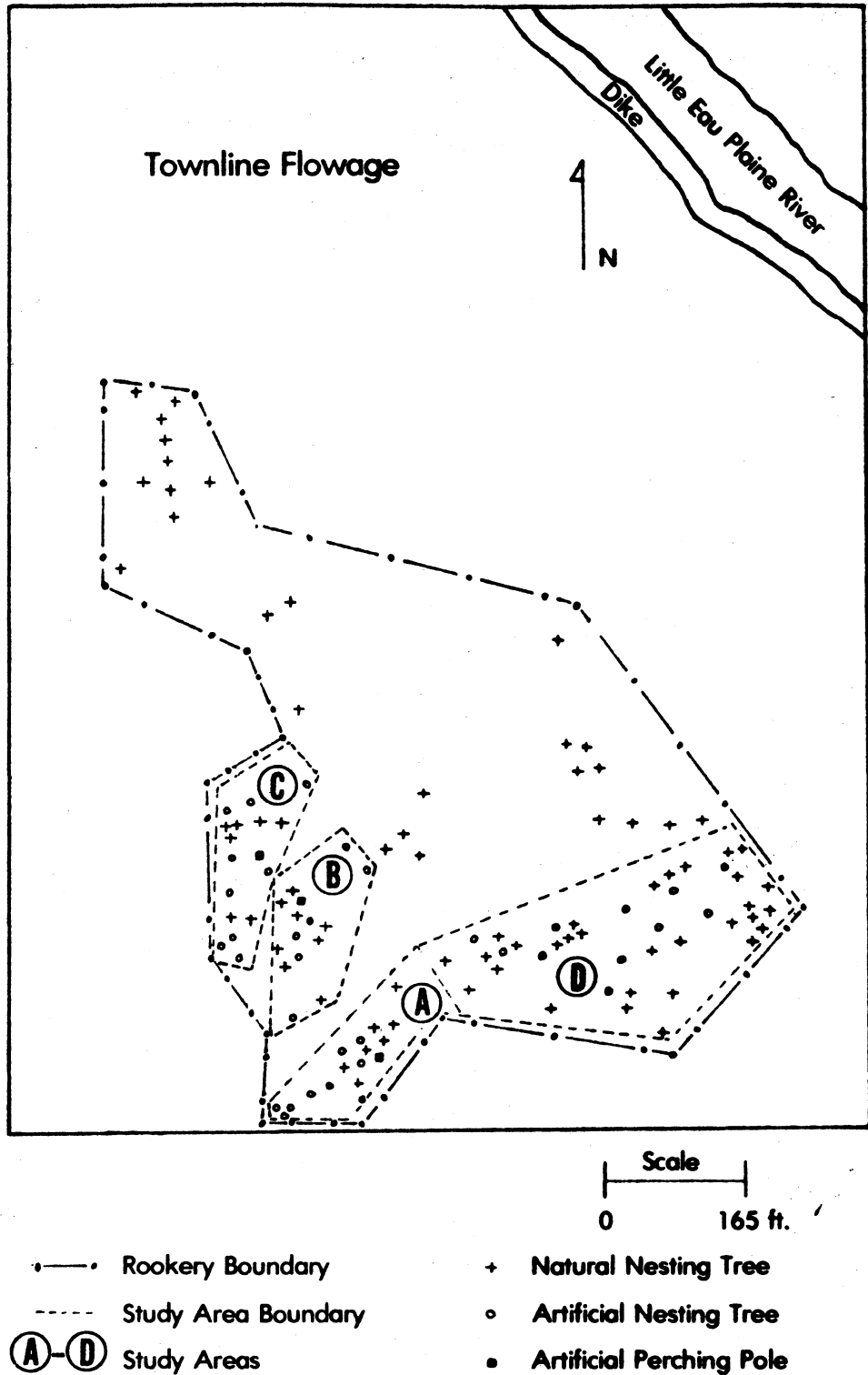


Fig. 2. Double-crested cormorant and great blue heron rookery on the George W. Mead Wildlife Area in central Wisconsin.

MATERIALS AND METHODS

Structure Construction

Artificial structures consisted of a 30- or 35-ft wooden pole with attached platforms. Construction, installation, and testing of structures was undertaken in 1974, 1975, and 1976. Pole site selection and structure construction took place in February and March of each year, when the ice was thick enough to support vehicles and heavy equipment. Snow depths in 1974 prohibited good ice formation and it became necessary to remove snow, on planned construction sites, with snowblowers to permit the ice to freeze sufficiently to insure safe conditions for heavy equipment operations.

Platform Types Tested

Three platform types were tested in the cormorant rookery during 1974. The rookery was divided into study areas corresponding to the 3 platform types (Fig. 2). Platform Type-A consisted of a wooden frame with 1-in mesh chicken wire stapled to the top surface (Fig. 3A). A 60-in perch, extending 18-in beyond each sidearm, was nailed to the front of the platform. Pieces of lath were used for the surface of Platform Type-B (Fig. 3B). Platform Type-C was constructed with a 19.5- x 12.5- x 8.0-in wooden box as the surface (Fig. 3C). A 2- x 2-in side brace was extended 55.5-in and 45.0-in out beyond the platform surface as a perch for Platforms Type-B and -C, respectively.

Platforms Type-B and -C were also used to test the feasibility of replacing fallen natural nests on artificial platforms; this was not repeated during 1975 or 1976.

Platform Type-B, with two modifications, was used almost exclusively

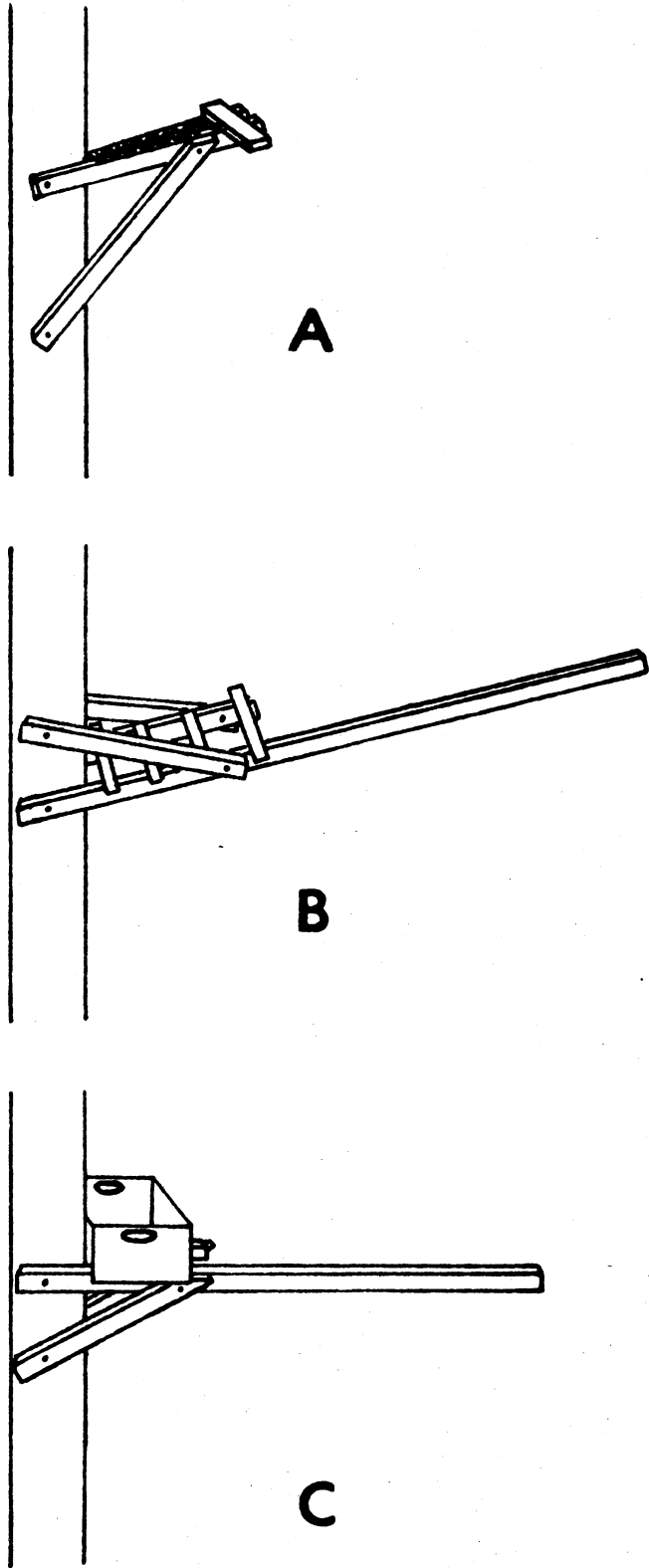


Fig. 3. Types of artificial nesting structures tested in 1974.

in each study area in 1975 (Fig. 4). Modifications included rounding off the square edges on the top surface of the perch with a joiner and extending the longest lath 14.75-in beyond the side of the platform to provide additional perching space.

Modified Platform Type-B was used for the construction of platforms in the heron portion of the rookery (Fig. 2, Study Area-D) in 1976. Platforms were not constructed in the cormorant portion of the rookery during this last year of the study.

One 8- x 8-ft square platform, successful for cormorants at the Agassiz National Wildlife Refuge in northwestern Minnesota (Cline and Dornfield 1968) was also constructed in Study Area-B.

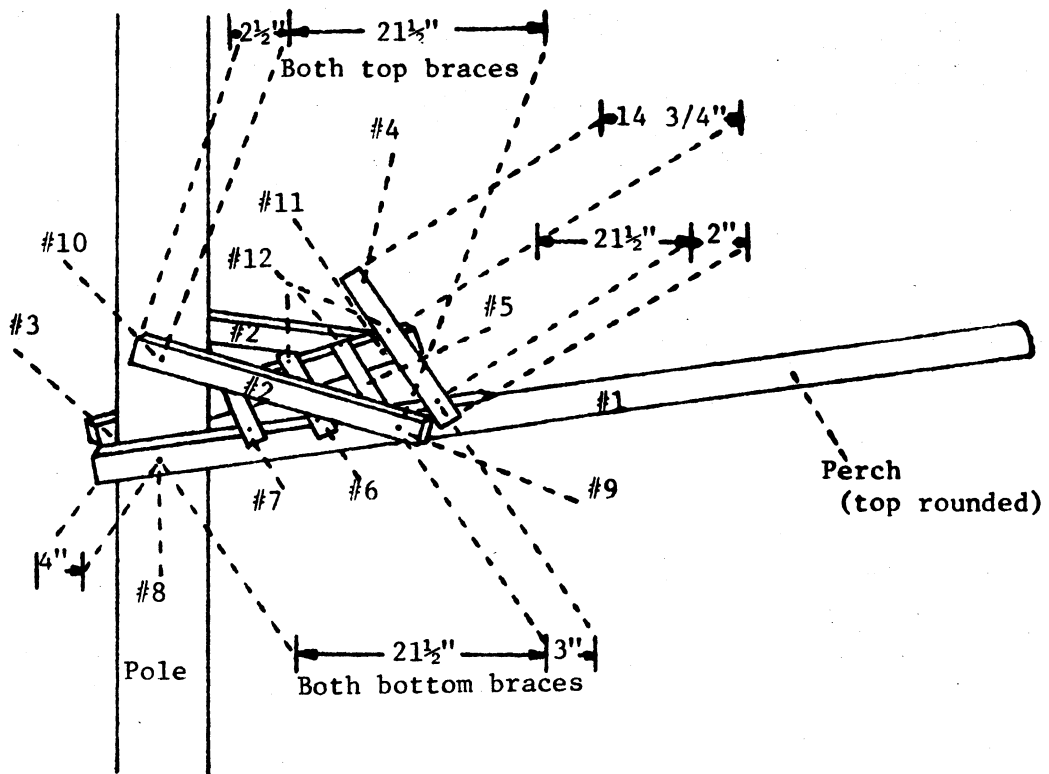
Perching Structures

A perching structure was placed in each study area (A-C), in 1975, to provide resting and roosting sites (Fig. 5). Each structure consisted of 3 perches attached horizontally to a 30-ft pole. Perches were constructed of 14-ft 2- x 2-in lumber rounded on the top surface.

Structure Placement

In 1974, 30-ft white ash and silver maple poles, with 6- to 8-in diameters at the base, were installed to accommodate the nesting platforms. The poles were placed in each study area as follows: 2 poles were placed within 25-ft of natural nesting trees, 1 pole 25- to 50-ft from natural nesting trees, and another pole 50- to 100-ft from natural nesting trees. An additional pole was placed in both Study Areas-B and -C to accommodate the replacement of fallen natural nests on artificial platforms.

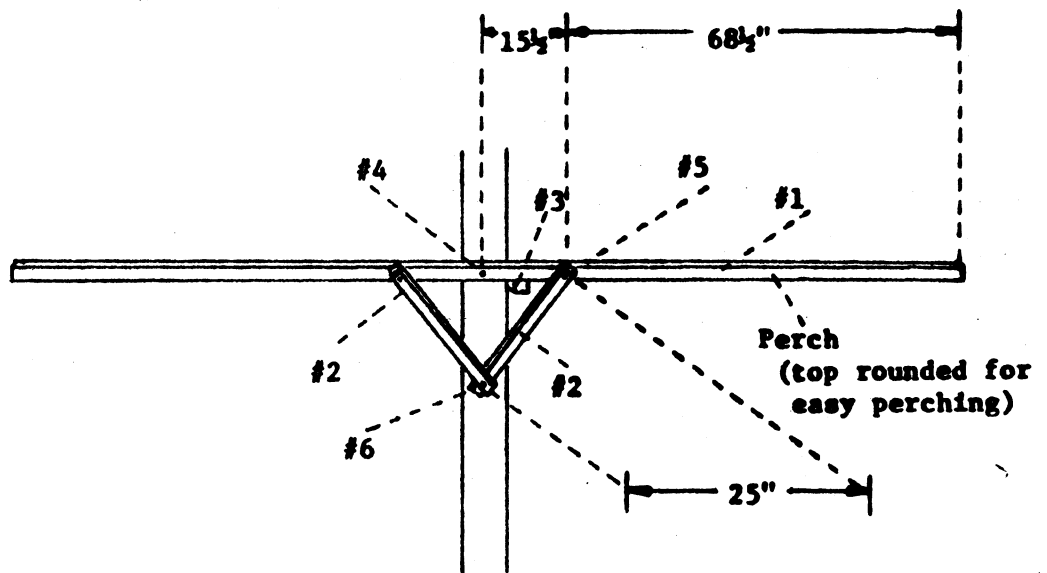
New and used, treated poles, with 8-in base and 5-in top diameters



Materials

- # 1 2"x2"x7'
- # 2 1"x2"x26 1/2"
- # 3 1"x2"x30"
- # 4 3/8"x2"x39" lath
- # 5 3/8"x2"x19 1/2" lath
- # 6 3/8"x2"x19 1/4" lath
- # 7 3/8"x2"x17 7/8" lath
- # 8 5/16"x3 1/2" lag bolt and washer
- # 9 5/16"x3" machine bolt and washer
- #10 5/16"x2 1/2" lag bolt and washer
- #11 5/16"x2 1/2" machine bolt and washer
- #12 1 1/4" ring shank nails

Fig. 4. Materials and measurements for construction of modified Platform Type-B



Materials

- #1 2"x2"x14'
- #2 1"x2"x27"
- #3 2"x2"x12"
- #4 5/16"x3 1/2" lag bolt and washer
- #5 5/16"x3" machine bolt and washer
- #6 5/16"x3 1/2" lag bolt and washer

Fig. 5. Materials and measurements for construction of perch for perching poles.

were used in 1975. New poles were purchased locally while used poles were obtained from the Fire Control Division of the Wisconsin Department of Natural Resources. All poles had been treated under pressure, with pentachlorophenol in a petroleum base. New and used poles had an estimated life expectancy of 45 and 20 years, respectively. One new 35-ft pole and 2 used 30-ft poles were placed within 25-ft of natural nesting trees in each study area. The long pole and one short pole were used for platform structures and the remaining short pole was used for the perching structure. Four 17-ft poles were placed in Study Area-B and served as legs for the Agassiz-type platform; one pole was placed at each corner of the square formation.

New treated 30-ft poles were used for structures in 1976 when 8 poles were placed in Study Area-D.

Site Selection

Soil and water depth determined the sites for pole placement. A clay layer, of varying depth, occurred over the main sand substrate within the rookery portion of the flowage. Pole placement sites were considered acceptable if the clay layer was at least 6.5-ft in depth and the water depth was no greater than 4.5-ft. Pole stability is essential and clay soils offer an excellent base for pole placement. Sandy soils will shift over time causing poles to lean from the vertical position. In loose soils it is necessary to riprap with rock around the poles to provide added stability.

Pole Installation

A 1.5- x 1.5-ft hole was cut in the ice with a chain saw. A hole was then drilled into the flowage floor with a hydraulic, 8-in auger mounted on the back of a truck. The auger was aligned with one corner

of the opening in the ice. Holes were drilled to depths of 4.5-, 6.0-, and 6.5-ft into the soil for 17-, 30-, and 35-ft poles, respectively. Pole and drill diameters were near equal. A point was cut on the butt of each pole prior to placement to facilitate the release of water pressure up the sides of the poles during placement.

A bulldozer, almost pole length away from and with its back toward the placement site, was used to lift poles vertically into place. The butt-end of the pole was placed against the corner of the hole and edge of the ice directly above the hole in the soil; the tip was placed on the top of the bulldozer cab. The pole was positioned by backing the bulldozer toward the pole site. The pole, when at approximately a 55° vertical angle with the ice, would slide off the edge of the ice shelf and drop to the flowage floor. The pointed butt of the pole would slide along the bottom toward the hole in the soil as the bulldozer continued backing; the hole in the ice acted as a pivot point. The pole would slide into the augered hole in the soil when it reached a verticle position. The bulldozer was then turned around and a chain attached to the blade and wrapped around the pole. The pole was forced to the desired depth into the hole by hydraulically lowering the blade. The amount of pole length above the water level available for platform or perch construction was a function of water depth.

Platform and Perch Construction

First-year platforms were constructed of old barn lumber and wooden boxes. Second and third year platforms, second-year perches, and the Agassiz-type platform were constructed from new southern yellow pine (*Pinus sp.*) lumber treated with chromated copper arsenate under 0.40 retention. This process was chosen over other methods of treatment

for its low toxicity and high estimated life expectancy (40 to 50 years). All materials and measurements for construction of modified Platform Type-B and perches are shown in Figs. 4 and 5, respectively.

Materials were precut, bolt holes predrilled, and platforms semi-constructed before going into the field. Semi-construction involved the joining of top and bottom braces for each sidearm with machine bolts. The longest lath on Platform Type-B was attached to the sidearms with a 21.5-in distance between nailing points. This preset the width of the platform surface. The Agassiz-type platform and perches for perching structures were constructed totally in the field.

Extension ladders were used to reach desired platform placement levels on the poles; construction began at the highest level and proceeded downward. Sidearms were attached to the pole with lag bolts; platform surfaces were nailed or stapled to them. Lag bolts were driven into poles with a hammer. Platform Types-A and -B were placed at a 7° angle above the horizontal to provide a pocket for nest placement. This angle was not used with the box platform because the box provided this effect.

Placement of Platforms and Perches on Poles

Platforms were positioned on poles in consecutive 90° staggered vertical placement, to preclude overlap. Platforms, in 1974, were spaced 3-ft apart vertically on 1 of the 2 poles placed within 25-ft of natural nesting trees, in each study area. Platforms were spaced 6-ft apart vertically on all remaining poles. Platforms were placed on each pole, beginning at the 18-ft level above water and proceeded downward to the respective spacing distance above the water. Natural

nests were placed on 2 platforms at the 6- and 12-ft levels in Study Area-B and on 1 platform at the 12-ft level in Study Area-C.

In 1975, all platforms were spaced 3-ft apart vertically, beginning 9-ft above the water level. Platforms extended to the 18-ft level and 24-ft level on 30- and 35-ft poles, respectively.

The Agassiz-type platform was built 9-ft above the water level.

Perches were attached at their horizontal mid-points, to foundation poles, with lag bolts. Vertical braces were attached to the perch with machine bolts and to the pole with lag bolts. A horizontal brace, was attached from the perch to the pole with nails to prevent rotational movement. Perches were placed at 12-, 15-, and 18-ft levels above water and at right angles to each other.

The placement pattern of platforms on poles in 1976 was modified to encourage great blue heron use. Platforms were spaced 4-ft apart beginning at the 8-ft level and proceeded to the 24-ft level in consecutive 180° staggered vertical placement.

Data Collection

An observation blind was placed atop a large stump 231-ft southwest of the rookery. Observations, in 1974 and 1975, began in April and continued through August. Observation periods, on a daily basis, were scheduled to include either morning, daytime, evening, or nighttime platform use and behavior observations. Data collected during observation periods included: date; weather conditions; the number and species of bird using platforms; minutes of bird occupation time; degree of nest construction; bird behavior; nest longevity in artificial and natural nest sites; and reproduction information. Cormorant production information was recorded for each active nest from the onset of incubation through

the fledging stage. Heron production was recorded for nests on artificial platforms only. Poor visibility of most natural heron nests precluded accurate observations.

Information gathered in 1976 pertained to general platform use by species, nest longevity, and final production.

RESULTS AND DISCUSSION

Use of Platforms for Nesting

A total of 8, 11, and 23 cormorant nests were constructed on artificial platforms in 1974, 1975, and 1976, respectively. This was 25.6, 26.8, and 57.5% of all nests constructed by cormorants on the study area in each respective year. The substantial increase in platform use for nesting purposes, observed in 1976, can be attributed to considerable deterioration of the natural nesting substrate during the winter of 1975-1976. Although the natural nesting substrate deteriorated, the cormorant spring resident population, adults and juveniles, within the rookery increased from 107 birds in 1974 to 124 in 1976.

A total of 3, 2, and 10 heron nests were constructed on artificial platforms in 1974, 1975, and 1976, respectively. This was 3.8, 2.3, and 9.4% of all nests constructed by herons, within the rookery, in each respective year. The increase in platform use observed in 1976 was due to platforms being placed on structures in the heron portion of the rookery during that year. Deterioration of natural nesting sites was advanced and the platforms were a suitable substitute.

Platform Use by Type

In 1974, Platform Type-B received 795% more use than Platform Type-A and 156% more use than Platform Type-C (Table 1). Birds were reluctant to land or walk on the chicken wire surface of Platform Type-A. A pair initiated nest building on only 1 such platform and abandoned it before construction was complete. No nests were constructed on Type-C platforms until all available Type-B platforms at or above the 9-ft level, and within 25-ft of natural nesting trees were occupied by

Table 1. Average platform use by type in 1974.

Study area	Platform type	Minutes cormorants occupied platforms ^a	Number of platforms ^b	Average use per platform (minutes)
A	A	2,114	8	264.3
B	B	16,552	7	2,364.5
C	C	7,380	8	922.5

^aRepresents time cormorants occupied platforms out of a total of 5345 observation minutes. More than one platform represents each value; each platform having the potential for 5345 minutes of observed occupation time.

^bNot all platforms of each type were available to cormorants due to occupation by great blue herons.

nesting pairs. The Type-B platform of 1974 was modified in 1975 to provide perching space adjacent to the platform surface which would facilitate a maximum family size of 2 adults and 4 young. The top surface of the main perch was also rounded to facilitate perching. This modified version received increased use over that of 1974 and was used more than other types in all study areas (Table 2). Modified Platform Type-B received 905% more use than Platform Type-A in Study Area-A. Comparison of modified Platform Type-B and the original Type-B platform in Area-B resulted in 204% greater use of the modified version. The alterations in platform construction in the development of the modified Type-B platform from the original Type-B platform are important and increase the desirability of this platform type. Modified Platform Type-B and Platform Type-C in Area-C received similar degrees of use but the high use pattern of Platform Type-C is misleading. The box construction of Platform Type-C permitted nesting material to accumulate and remain within the nest box until the 1975 nesting season. Cormorants use nests from year to year unless they are destroyed (Mendall 1936). This was observed on 2 Type-C platforms which became occupied early in the 1975 breeding season and biased the Platform Type-C data when it was compared to modified Platform Type-B. These 2 platforms accounted for 71.8% of the use recorded for Platform Type-C. The high level of use recorded for the Type-B platform over the Type-C platform in 1974 is more representative of the comparison of these platform types, but further testing may be necessary to more precisely determine the desirability of one over the other.

The Agassiz-type platform was not used by the Mead cormorants in 1975. This type of platform was used at Agassiz when its existing rookery had deteriorated to a point where birds were nesting on floating

Table 2. Average platform use by type in 1975.

Study area	Platform type	Minutes cormorants occupied platforms ^c	Number of platforms	Average use per platform (minutes)
A	A	0	9	0
	B ^a	3,620	10	362.0
B	B ^b	2,680	9	297.2
	B ^a	8,156	9	906.2
C	C	9,200	9	1,022.2
	B ^a	12,080	10	1,208.0

^aModified B type platform.

^bOriginal B type platform.

^cRepresents time cormorants occupied platforms out of a total of 3900 observation minutes. More than one platform represents each value; each platform having the potential for 3900 minutes of observed occupation time.

mats of vegetation. The Mead rookery had not reached this stage of habitat deterioration.

Platform Type-B, original and modified, received 93% of all heron nesting activity in artificial platforms during the study. One successful nest was constructed on a Type-A platform while no nesting attempts occurred on Platform Type-C.

The modified version of Platform Type-B is recommended for future restoration of deteriorating cormorant and heron rookeries. The design permits the birds to weave nesting material around the platform supports in a natural fashion and provides good aeration of the nest to prevent waterlogging and subsequent rotting of the platform surface. Mendall (1936) states that the cormorant seldom uses weaving in the nest building process. This is contrary to my observations at the Mead where cormorants frequently weaved nesting material into their nests and around the platform supports.

Structure Use in Relation to Distance from Natural Nesting Trees

Structures placed within 25-ft of natural nesting trees received an average of 98.2% of all recorded cormorant use during 1974 and 1975 (Table 3). Structures placed at 25- to 50-ft and 50- to 100-ft from natural nesting trees received only an average of 1.7 and 0.1% of recorded use respectively.

Structures placed within 25-ft of natural nesting trees received an average of 99% of all recorded heron use during 1974 and 1975. Structures placed at 25- to 50-ft and 50- to 100-ft received a combined average of 1% of the recorded heron use during the same period.

Structures should be placed within 25-ft of natural nesting trees, when present, to facilitate use by cormorants and herons. Clear aerial

Table 3. Nesting structure use in relation to distance from natural nesting trees.

Distance of structure from natural nesting trees	Year	Number of structures	Minutes cormorants occupied structures ^a	Number of platforms all structures	Average use per platform (minutes)
0-25 ft	1974	6	26,046	23	1,132.4
	1975	12	35,736	54	661.7
25-50 ft	1974	3	944	9	104.8
	1975	3	136	9	15.1
50-100 ft	1974	2	1	6	.2
	1975	2	56	6	9.3

^aRepresents time cormorants occupied platforms out of a total of 5345 and 3900 observation minutes for 1974 and 1975 respectively. More than one platform represents each value; each platform having the potential for 5345 and 3900 minutes of observed occupation time for 1974 and 1975 respectively.

access to platforms is important and can be assured by placing structures 20-ft apart. Clumping of structures in groups adjacent to natural nesting trees will maximize the restoration potential of main nesting areas within the rookery. Expansion will then take place from these restored nesting nuclei.

Platform Use in Relation to Height Above the Water

Platform use increased with an increase in height, above water, in 1974 and 1975 (Table 4, Fig. 6). One-hundred percent of the nests built on artificial platforms occurred between the range of 9- to 24-ft. This corresponds to the vertical range for natural nest sites of 8- to 27-ft. The slight reduction in use at the 24-ft level in 1975 is a product of one platform becoming permanently occupied for nesting purposes late in the breeding season. Observations of platform use were terminated before young had fledged from this nest and resulted in a lower degree of recorded use for this platform level. Lewis (1929) records nesting heights, in tree nesting colonies, ranging from 1- to 65-ft or higher above the ground or water.

Hérons used either of the top 2 platforms on any given structure throughout the study. These platforms ranged from 18- to 24-ft above the water and were within the height range occupied by nests in natural sites.

Providing artificial platforms within the vertical interval occupied by natural nests will maximize platform use. In rookeries where excessive deterioration precludes this determination, the 9- to 24-ft vertical interval should be used.

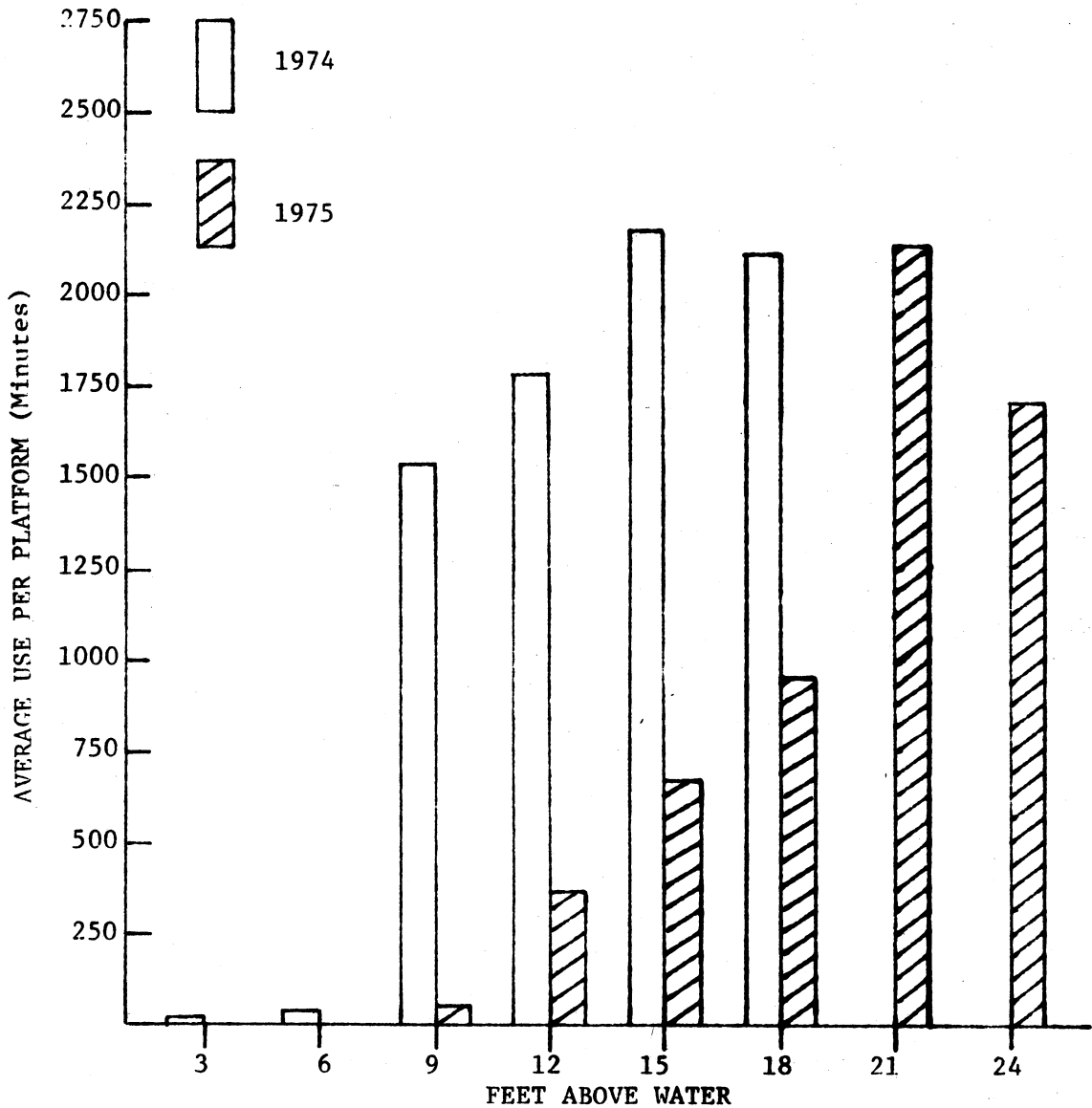


Fig. 6. Cormorant use of platforms in relation to height above water.

Table 4. Platform use in relation to height above water.

Height of platforms above water	Year	Number of platforms	Minutes cormorants occupied platforms ^a	Average use per platform (minutes)
3 ft	1974	3	14	4.7
	1975	3	0	0
6 ft	1974	6	121	20.2
	1975	6	0	0
9 ft	1974	3	4,566	1,522.0
	1975	9	236	26.2
12 ft	1974	6	10,567	1,761.2
	1975	12	3,876	323.0
15 ft	1974	3	6,545	2,181.7
	1975	9	6,164	584.9
18 ft	1974	2	4,233	2,116.5
	1975	11	10,588	962.5
21 ft	1974			
	1975	3	6,440	2,146.7
24 ft	1974			
	1975	2	3,444	1,722.0

^aRepresents time cormorants occupied platforms out of a total of 5345 and 3900 observation minutes for 1974 and 1975 respectively. More than one platform represents each value; each platform having the potential for 5345 and 3900 minutes of observed occupation time for 1974 and 1975 respectively.

Platform Use in Relation to Vertical Distance Between Platforms

Vertical distance between platforms had little effect on platform use. Platforms spaced 3-ft apart had an average use of 1,086 observation minutes per platform in 1974 and 668 observation minutes per platform in 1975. Platforms spaced 6-ft apart averaged 1,220 observation minutes per platform in 1974 and 556 observation minutes per platform in 1975. The 3-ft spacing distance between platforms approximates the average 2.9-ft vertical spacing between nests in natural trees. This recommended spacing distance has the added advantage of facilitating more platforms per pole.

The 4-ft spacing distance used in platform construction in 1976 facilitated heron nesting on platforms below the top level on any given structure. Interference between cormorants and herons seldom occurred within the rookery. Interference did occur occasionally when a cormorant nesting directly beneath a heron would steal nesting material from the nest above. I recommend a 4-ft spacing distance between platforms in those areas of a rookery where both species nest side by side.

Effect of 90° Vertical Rotation on Platform Use

Positioning of platforms in consecutive 90° staggered vertical placement was accepted by the cormorants. However, this pattern did allow defecations from upper nests to fall on the nests directly below. This was not uncommon in natural trees but it occurred more frequently in artificial structures.

Heron use of structures for nesting was limited to the top platform on any given pole during 1974 and 1975. The 90° rotation pattern did not provide a desirable nesting site arrangement. A consecutive 180° staggered vertical placement was used exclusively in the placement of

platforms on all structures constructed in 1976. This modification reduced defecation problems and facilitated heron use of lower platform levels. I recommend the 180° rotation pattern for future construction.

Replacement of Fallen Nests on Platforms

Placement of fallen nests on platforms was tested during the first year of the study to determine if this technique was necessary to initiate platform occupation. Three fallen natural nests replaced on artificial platforms were readily accepted. However, all but one were blown out of the platforms by high winds early in the breeding season. The remaining nest was occupied by a pair of cormorants that subsequently nested successfully. One of the platforms continued to be occupied by a nesting pair after nest loss. This pair renested and produced 3 young. Renesting is not uncommon and has also been observed by McLeod and Bondar (1953). This technique may be desirable when attempting to develop new rookeries. Cormorants often feed in areas where nesting sites are not available, but where the establishment of artificial nesting structures is feasible. The presence of nests, obtained from active colonies, on selected platforms may encourage nesting. All replaced nests should be wired into their respective platforms to prevent loss from high winds.

Use of Perching Structures

Perching structures received varying use dependent upon the number of cormorants present in a particular study area. The perching structure in Study Area-A received 6 minutes of observed use out of a possible 3900 minutes of observation time logged during the 1975 breeding season; the pole in Area-B received 68 minutes, and the one in Area-C received

301 minutes. Area-A was occupied at any given census period by approximately 10% of the Mead population while Areas-B and -C contained 42 and 48% of the population, respectively. Perching structures will become increasingly important as natural roosting trees within a rookery deteriorate. They should be incorporated into rookery restoration plans when this particular aspect of the habitat is lacking.

Perching structures were not located in the heron portion of the Mead rookery. Structures placed in the cormorant portion of the rookery received 38 minutes of observed heron use during the 1975 breeding season. This use occurred from herons occasionally using the area for resting and roosting. Perching needs and requirements of the heron are similar to the cormorants and I recommend that perching structures be incorporated into heron rookery restoration plans.

Production

Production from nests on natural nest sites averaged 2.34, 1.30, and 2.18 young per nest for 1974, 1975, and 1976 respectively. Production from nests on artificial platforms averaged 2.50, 1.18, and 2.82 young per nest during the same respective period (Tables 5, 6, and 7). Productivity in this study reflects the average clutch size of 3 eggs per nest recorded by Bent (1964) and approximates the average 2.4 young per nest recorded by Norton (1973). While nests normally possessed 2 to 4 young, 1 nest in 1976 contained 5 young; all fledged successfully.

Natural nesting trees were in advanced stages of deterioration and active nests were easily destroyed when limbs broke off during stormy weather. Artificial platforms were more secure because of their stability and resistance to deterioration. The deteriorated condition of the natural trees was responsible for the loss of 13, 13, and 35% of the

Table 5. Cormorant production, 1974.

Study area	Total nests		Successful nests		Number of young fledged		Average fledged young per nest	
	A ^a	N ^b	A	N	A	N	A	N
A	1	4	0	3	0	9	0.00	2.25
B	4	11	4	9	12	27	3.00	2.45
C	3	14	3	12	8	32	2.67	2.29
Replaced nest (B)	1		1		3		3.00	
Replaced nest (C)	1		1		2	1	2.00	
Total	10	29	9	24	25	68	2.50	2.34

^aArtificial platforms.

^bNatural nest sites.

Table 6. Cormorant production, 1975.

Study area	Total nests			Successful nests			Number of young fledged			Average Fledged young per nest		
	A ^a	A ^b	N ^c	A	A	N	A	A	N	A	A	N
A	0	2	2	0	1	2	0	2	6	0.00	2.00	3.00
B	0	2	14	0	0	6	0	0	11	0.00	0.00	0.79
C	2	5	14	1	4	11	1	10	22	0.50	2.00	1.57
Total	2	9	30	1	5	19	1	12	39	0.50	1.33	1.30

^a1974 platform type for each respective area.

^bModified platform type B.

^cNatural nesting sites.

Table 7. Cormorant production, 1976^a.

Study area	Total nests			Successful nests			Number of young fledged			Average Fledged young per nest		
	A ^b	A ^c	N ^d	A	A	N	A	A	N	A	A	N
A	0	4	1	0	4	1	0	13	3	0.00	3.25	3.00
B	0	6	5	0	6	3	0	19	13	0.00	3.17	2.60
C	4	4	8	2	4	6	5	15	18	1.25	3.75	2.25
D		5	3		4	1		13	3		2.60	1.00
Total	4	19	17	2	18	11	5	60	37	1.25	3.16	2.18

^aProductivity could not be determined in 10 nests, 5 in artificial platforms and 5 in natural nesting trees. These nests are not included in this table.

^b1974 platform type for each respective area.

^cModified platform type B.

^dNatural nesting sites.

active nests in natural nest sites during stormy periods in 1974, 1975, and 1976, respectively. This corresponds with a loss of 0, 9, and 13% of the active nests on artificial platforms over the same period.

Some nests were lost because of human disturbance and predation. The extent each of these factors played in nest abandonment was difficult to determine. Collectively they accounted for the loss of 3, 23, and 0% of the active nests in natural nest sites in 1974, 1975, and 1976, respectively. This corresponds with a loss of 0, 36, and 0% of the active nests on artificial platforms during the same period. The high loss of active nests in 1975, beyond those destroyed during stormy weather, was due to intense human disturbance within the rookery and suspected predation by great horned owls (*Bubo virginianus*). Canoeists entered the rookery to investigate the nesting birds twice during the breeding season. On the first occasion the adult segment of the cormorant population flew off and did not return for over 30 minutes. At this time newly hatched young may have become over exposed to the burning rays of the sun. On the second occasion, the same canoeists observed young jumping from the nests and either drowning or dispersing. Human disturbance as a mortality factor has been reported by Houston (1962), and Erskine (1972). Human activity in a cormorant rookery should be restricted during the entire breeding season.

A pair of great horned owls nested in an old great blue heron nest on the south edge of the rookery, in 1975, and raised 2 young. Throughout the cormorant and heron breeding season it was not uncommon to hear the entire rookery reverberate with alarm calls from both species during the nighttime hours. Observations on days following this type of disturbance generally resulted in missing cormorant

young or newly vacated nests. Norton (1973) observed an active great horned owl nest in the middle of the Woods Hole rookery in Oklahoma. Predation by other species has been reported in other colonies throughout North America. Kees (1970) reported predation of young and eggs by crows (*Corvus brachyrhynchos*) in British Columbia and of eggs by California gulls (*Larus californicus*) in California. Lewis (1929) reported predation of eggs and young by the great black-backed gull (*Larus marinus*).

The average number of fledged young per nest, in this study, ranged from 1.30 to 2.34 and 1.18 to 3.16 for natural nests and nests on artificial platforms respectively. This fluctuation can be attributed to yearly variations in weather patterns, predation, and human disturbance.

Eight known renests were observed over the 3 year period. It was difficult to determine the extent of reneest attempts within the Mead population because the birds were not banded or marked.

Heron production in platforms in 1974 and 1976 was 1.6 and 2.8 young per nests respectively. Production information was not obtained from the 2 nests on platforms in 1975. Production was not recorded in natural nests but productivity in 1976 approximated the rate of 2.18 to 2.70 young per successful nest recorded by Werschkul et al. (1977).

Structure Costs

I recommend treated poles and platforms for construction of artificial nesting structures and perching structures for the double-crested cormorant. The high life expectancy of treated wood materials out-weighs initial cost. Material costs for nesting structures in 1980 were as follows: treated 30-ft pole--\$50.00 per pole; treated 35-ft poles--\$90.00 per pole; treated platforms--\$3.75 each. The number of platforms able to be placed on a pole is dependent on water depth. A 30-ft pole at the

Mead rookery held 4 platforms and a 35-ft pole held 6 platforms. Total cost per completed structure including labor and materials averaged \$125.00 for 30-ft structures and \$200.00 for 35-ft structures. Total cost per platform averaged \$31.25 and \$33.00 for 30- and 35-ft structures respectively.

Material costs for perching structures in 1980 were as follows: treated 30-ft pole--\$50.00 per pole; perches and bracing--\$3.65 each. A 30-ft pole at the Mead held 3 perches. Total cost per completed structure including labor and materials average \$97.75. Total cost on a per perch basis averaged \$32.58.

Platforms and perches should be inspected and repaired annually prior to the breeding season. This can best be done in the winter when ice facilitates inspection and repair work. At the Mead, repairs were minimal and generally involved replacing and tightening bolts or replacing broken perches, sidearms and lath.

CONCLUSION

Artificial platforms were a successful substitute for the cormorant's natural nesting substrate. Great blue heron use of platforms, in addition to cormorant use, increases the possibility of rehabilitating deteriorating rookeries containing either or both species.

Anderson and Hamerstrom (1967) stated that cormorant population declines appeared to be associated with man's disturbance of cormorant habitat. In the past, beaver (*Castor canadensis*) most likely created nesting habitat for tree nesting cormorants by flooding forested areas. Intensive control of beaver activity over much of Wisconsin today precludes the continuous creation of nesting habitat by natural means. Hence, the construction of an artificial nesting substrate appeared to be a possible solution to the problem of deteriorating habitat.

Current beaver management policy in the state of Wisconsin should be reviewed and evaluated; adverse affects similar to those experienced by the cormorant may be occurring to other species closely related to the beaver's ecology.

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